認知負荷軽減を指向した再構成型概念マップにおける自動レイアウトと記憶保持におけるトレードオフ

Automatic Layout in Closed Concept Map for Cognitive Load Reduction and The Trade-off in Memory Retention

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Abstract: Concept maps construction has been used to improve reading comprehension. One specific type of concept map made possibly by software use are closed concept maps. When building closed concept maps, users build the maps from a given set of pieces. However, the large number of pieces can overwhelm the working memory of the users, who also have to manage the layout of the maps. This work proposes Airmap, a closed concept map interface that attempts to solve these problems by adding an automatic layout function to closed concept map construction. Past experiment results are summarized.

1 Introduction

Comprehending information is important when reading for learning. It is a process of connecting the information presented in the text to prior knowledge. When education moves on to comprehension-related skills instead of earlier reading skills like word recognition, some students start falling behind[1, 2]. This problem happens more often in readers from low-income families[3]. Concept maps have been successful in improving reading [4, 5, 6, 7, 8]. A concept map is a graphical tool used to represent knowledge. It is composed of concepts and of links between the concepts. One explanation of how concept maps help comprehension is the idea that they provide a template, which helps organizing and structuring information[9]. Another explanation is that graphical structures, like a concept map, are closer to the macrostructure of a text, which makes it easier to understand[10]. Furthermore, building the map allows students to continuously process the concepts [11].

Another point of concern when learning from reading is retention. Information not only has to be comprehended, it also has to be retained so that students can use it later. Concept map use has also been said to improve retention, with mechanisms similar to how it aids in comprehension, such as aiding in knowledge organization and continuous processing[9, 11, 10]. One study found that fifth-grade students who created a concept map had higher post-test scores after a two-week retention period[12]. Another study, also featuring fifth graders, found that students who used a concept map to visualize an electronic portfolio outperformed students who visualized the same portfolio through a tree structure after a three-day retention period[13]. A meta-analysis of studies using concept maps reported that concept maps were effective for both retention and transfer[14]. This holds true for both studying through map construction and through map visualization.

Computer-based tools have been used in previous research [15, 16, 17]. Normally, in concept mapping, students have to create and label the concepts and links by themselves. However, some of these tools ask students to assemble the map from pre-generated and

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pre-labeled concepts and links instead[18, 19]. These maps are called closed concept maps because the set of maps that can be created is finite.

The map building process for closed concept maps can create a situation where the student is overwhelmed by the amount of information provided on the screen. In this situation, the student has to understand, organize, and connect the links and nodes that somebody else defined. This can put a heavy load in the working memory of the student. This load is called the cognitive load. Different learning activities impact cognitive load differently, which in turn impact learning performance[20].

It is possible to reduce cognitive load by changing the design of the tool[21]. Changing how information is organized in the screen or automatizing parts of the activity are examples of design changes that can impact cognitive load. Also, comparing different interfaces which incur different types of cognitive load has the potential to reveal information about how exactly the activity affects learning. No study so far, to the best of our knowledge, has attempted to reduce the cognitive load in concept map building interfaces and measure how it affects different aspects of learning, despite the potential for optimizing the map building process and for revealing new aspects of learning from concept maps.

This work describes Airmap, an interface for building concept maps from pre-existing parts focused on reducing cognitive load. Airmap employs a combination of automated layout and information separation. The work also describes past results of experiments involving Airmap. This is an ongoing effort on exploring different closed concept map interfaces and how they affect learning[22].

2 Methodology

In this section Airmap will be introduced, alongside how it attempts to reduce cognitive load.

The interface of Airmap can be seen in Figure 1. On the right side of the screen, Concept 1, Concept 2 and Concept 3 are the nodes of the concept map. Users can select nodes, which will have frames around them. In the figure, Concept 1 and Concept 2 are selected. Furthermore, when two concepts are selected, they

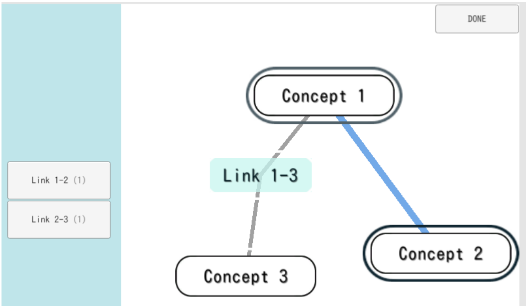

図1　The interface of Airmap

become connected by a thick line. The user can then choose a link to connect those two nodes. The user chooses links from the link menu positioned in the left side of the screen. In the figure, Concept 1 and Concept 3 are already connected by link ”Link 1-3”.

When users wish to disconnect two nodes they can do so by clicking on the link that connects them. This erases the link and returns the nodes to their previous unconnected state. The user is then free to reuse that link label to connect other nodes.

Unlike other concept map building tools, the user is not burdened with managing the layout of the concept map. In fact, in Airmap the user cannot manage the layout. The algorithm used to handle the layout is a type of force-directed graph drawing algorithm[23]. The implementation used can be found in [24].

3 Comparative Analysis with Kit-Build Concept Map

Experiments have been done comparing Kit-build to Airmap[22]. Kit-build is a closed concept map interface where the students have to manage the layout of the map[25, 18]. The experiments measured cognitive load metrics and reading comprehension metrics. Results showed that Airmap has significantly lower cognitive load than Kit-build. Furthermore, results show that Airmap is not significantly different than Kit-build in immediate reading comprehension. However, Kit-build outperforms Airmap after a two-week retention period. Results suggest that the cognitive load reduced is useful for improving retention of knowledge. As such, Airmap may be better suited for understanding a subject, while Kit-build is more useful for commiting information to memory.

4 Conclusion

Concept maps and closed concept maps are effective learning methods. However, closed concept map construction can overwhelm the working memory of students. This work proposes Airmap, an interface which uses automated layout and information separation to lower the cognitive load when building the maps. The automated layout uses a physics based algorithm to automatically organize the concepts and links.

Results obtained in past experiments suggest that Airmap is successful in reducing cognitive load. It also suggests that Airmap is useful for comprehending information but not to enhance retention. Currently, an analysis of what type of information and learning context benefit most from the use of Airmap is being performed. Furthermore, the process of map building is being used to further examine learning gains. That is, intermediary artifacts created during the building process are being used to explain the learning mechanics from map building. These analyses have the potential to improve learning from closed concept maps in the future.

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